SERVICE INSTRUCTIONS

section DG

DIGIT - INSERTION UNIT _ DI-3

P/N 1164-4010
(Used only in the Type 1164 Synthesizer)

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GENERAL RADIO COMPANY

West Concord, Massachusetts

SECTION DG-1

INTRODUCTION

DG-1.1 GENERAL.

The information contained in this section supplements the over-all operation and instrument-maintenance instructions that appear in the front of this manual. This section is prepared with a modular point of view. It is intended to furnish detailed information necessary for proper field maintenance (in the event of module failure), as indicated by paragraph 5.6 "System Trouble-Analysis".

Included in the following paragraphs are a physical description and signal-flow discussion of the module sufficient for comprehension, by experienced service personnel, of the principles of operation. A trouble-analysis procedure that will aid in isolating the defective circuit completes the section.

To facilitate part identification, reference designators used in the text and on the photographs are the same as those that appear on the complete schemetic diagram and in the parts list. The reference designators are silk-screened on the module as a further aid in part location.

The service instructions are written to facilitate use of a properly functioning synthesizer as a basic test frame for the module. The instrument can be used to support the module, in a convenient bench-service position, and to supply it with power and test signals.

NOTE

First consideration should be given to the use of the widespread General Radio Company service organization to repair a defective module, particularly on an instrument still within the two-year warranty coverage.

DG-1.2 PURPOSE.

The DI-3 Digit-Insertion unit is employed in the General Radio Type 1164 70-MHz Coherent Decade-Frequency Synthesizer to furnish the dial-selected 10-MHz steps in the instrument output. It differs completely in function and electrical design from other Digit-Insertion units in the instrument and, although of a very similar mechanical configuration, is not interchangeable with other types of Digit-Insertion units. Mounting arrangements in the chassis are identical with those for the other digit units, comprised of two screws through the front panel to the top of the unit and a hold-down clamp at the rear.

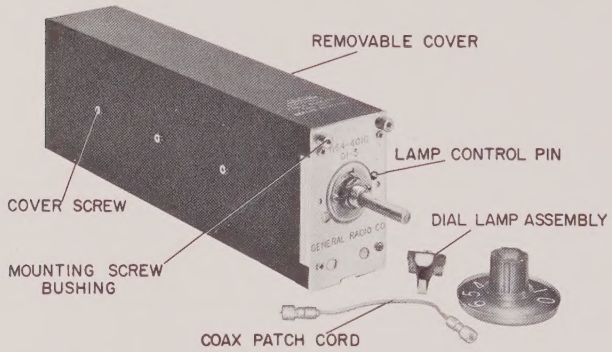


Figure DG-1. DI-3 Digit-Insertion Unit module.

DG-1.3 DESCRIPTION.

DG-1.3.1 MECHANICAL LAYOUT.

The mechanical layout of the DI-3 module is very similar to that of other DI units and consists of an assembly of four etched boards, which contains all of the electrical components that form the DI-3 circuitry.

Sheet-metal rails, on the long edges of the two larger circuit boards, run the length of the unit. Threaded inserts on these rails fasten the entire assembly. A central sheet-metal shield provides electrical isolation and additional mechanical support for the structure. Spool inserts in the edge of this shield plate serve as anchor points for the module cover.

The front of the unit consists of an etched-circuit board and structural parts. This front etched-circuit board carries the dial-lamp control circuitry. A pin on the board projects through the front of the module (see Figure DG-1) to establish electrical contact with the DI-3 dial-lamp error-sensing probe on the chassis front panel. A plate in front of this etched board carries the digit-selector switch detent mechanism. Spring contacts of finger stock around the perimeter of the front panel make a tight electrical seal with the mouth of the outer cover.

The rear of the module consists of a vertical etched board which carries the Digit Oscillator (see paragraph DG-2.3). Rotary-switch wafers, operated by the front-panel control, select among seven tuning coils that are mounted on a separate plate, on posts from the vertical etched board. The coils are positioned in such a way that the oscillator tuning adjustments are all accessible from the rear.

CAUTION

These coils are not intended for field adjustment.

The switch shaft, with insulated rear section, runs the entire length of the module, just above the center shield partition.

The bottom board of the assembly carries two jacks and one ground-pickup pin, which engage contacts and banana plugs projecting from the sandwich deck. A subminiature coaxial connector that carries the 150-120-MHz output of the DI-3 assembly, projects from the bottom of the module, near the front.

A removable sheet-metal cover, which slides over the back of the unit, encloses the module on five sides. The cover is secured with eight 4-40 screws, three per side and two on the bottom. The cover, in addition to mechanical support and protection, provides electrical shielding for the more sensitive circuits in the module. Alignment of the unit is affected considerably by the presence or absence of this cover; consequently, the cover must be in place if the module is to function properly.

Interconnection between the etched boards is made, with one exception, by wire links at the edge of the boards. The exception is the miniature coaxial cable, near the center, that passes through a hole in the center shield partition.

DG-1.3.2 ELECTRICAL CHARACTERISTICS.

The DI-3 unit supplies signal outputs, frequency coherent with the master quartz oscillator in the AFS unit, necessary to produce the 10-MHz digit steps in the Type 1164 synthesizer. The function of this module in the operation of the Type 1164 system is described in Section 4 of the front portion of this manual.

To form the seven frequency steps (150 to 120 MHz) coherently from the master crystal oscillator, the DI-3 accepts as an input a 5.0 MHz sinewave from the sandwich deck. The 5-MHz signal is generated in the AFS unit, by the 5-MHz crystal oscillator (refer to Section CA of this manual). This 5-MHz input to the DI-3 is used as the reference to phase-lock an oscillator, which has been rough-tuned by the dial switch, to any one of the desired 150 to 120-MHz output frequencies of the DI-3. This principle is discussed more fully in Section DG-2.

The other external connections for the DI-3 consist of the +18-volt No. 1 input from the power supply and the external lamp-control pin. The lamp-control circuit is so arranged that, if the digit oscillator fails to lock, the lamp-control pin is de-energized and extinguishes the lamp in the lamp-control assembly on the front panel, to give warning of failure.

SECTION DG-2

PRINCIPLES OF OPERATION

DG-2.1 GENERAL.

In this section, reference is made to the elementary block diagram, Figure DG-2, and the complete schematic diagram, Figure DG-14.

The principle circuit in the DI-3 is a sampled-data, automatic phase-control system which uses 5 MHz as a reference signal to lock a rough-tuned oscillator to a multiple of 5 MHz, chosen in the band of frequencies from 120 to 150 MHz.

The 5-MHz sinewave input is converted to a short-duration, high-peak-power pulse with a 5 MHz repetition rate. This pulse is used to operate a gate connected to the output of the digit oscillator which, when opened by the pulse, connects the output of the oscillator to a holding capacitor that stores the instantaneous value of the oscillator output voltage when the sampling pulse occurs. If the oscillator is tuned exactly to an integer multiple of the 5-MHz input, the value of the sample is the same each time and the voltage on the holding capacitor is dc. If there is a difference between the oscillator frequency and the corresponding multiple of the 5-MHz input reference, a step-wise sinewave signal results, which represents the drift between the oscillator and the closest multiple of the 5-MHz reference. The amplified holding-capacitor voltage is used as an error signal to phase-lock the oscillator. Figure DG-3 shows the nature of this error signal.

Since an ac component of error signal is present only when the oscillator is not locked, it can be used to indicate malfunction. In the DI-3, the error

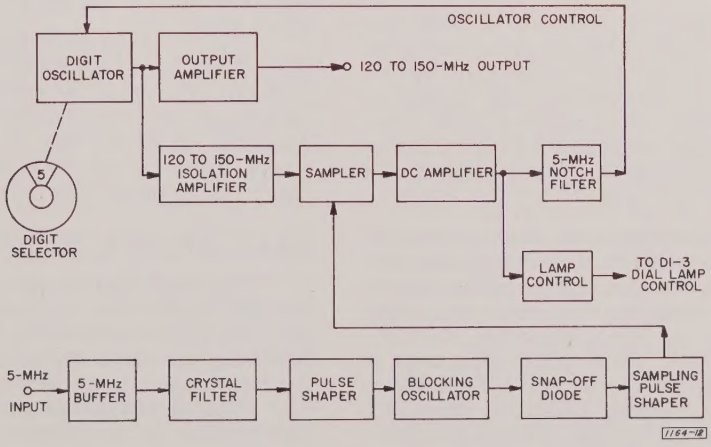


Figure DG-2. Block diagram.

signal is sensed for presence of ac and, if ac is found, the dial lamp is extinguished (refer to paragraph DG-2.7).

The operating principles of individual circuits are discussed in more detail below.

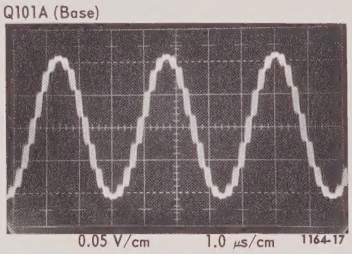


Figure DG-3. Step-wise sinewave signal at the base of Q101A indicative of the operation of the sampler circuit in response to oscillator drift.

DG-2.2 PULSE GENERATOR.

The 5-MHz signal from the sandwich deck enters the DI-3 via J203, where it feeds the 5-MHz amplifier Q205/T205, which is located on the bottom etched-board assembly. The output of this amplifier feeds a crystal filter, located on the front board. The filter removes 100 kHz and 1 MHz sidebands, present in small amounts on the input signal, to ensure a clean DI-3 output signal.

The output of the filter feeds the pulse shaper on the top board. The pulse shaper is comprised of the circuits involving Q103 and Q104, which are connected as an emitter-coupled clipper.

Q104 is biased at 9 V, and the 5-MHz output of Q205 is fed to the base of Q103. This arrangement results in a 5-MHz square-wave current in the collectors of Q103 and Q104. The current in Q104 is fed to L107, which rings at its self-resonant frequency for one-half cycle (or until CR105 conducts, dissipating the energy in L107).

The resulting pulse is amplified in Q105 and another self-resonant choke, L108, shortens the spike further. This spike triggers the monostable blocking oscillator Q106/T102, and the blocking oscillator cycles once for each pulse received from Q105. The amplitude of the blocking oscillator is controlled by R128. Waveforms of these various parts of the circuit can be seen in Figure DG-7 and DG-8.

The load for the blocking oscillator consists of R127 and a snap-off diode, CR106, at the end of a coaxial delay line, Z101. When the blocking oscillator turns on negatively, CR106 turns on also, since its anode is effectively grounded for low frequencies, through delay lines Z102 and Z104. While it is conducting, a certain amount of charge is stored in the diode junction so that, when the blocking oscillator turns off abruptly, the diode retains its high conductance (because of the mobile carriers in its junction) until the charge is swept out. Then, as the stored charge is abruptly exhausted, the diode turns off in a small fraction of a nanosecond (Figure DG-8).

This sharp transition creates a negative pulse at the anode of CR106, which propagates down Z102 until it reaches the junction of Z102, Z103, and Z104. The reflection of this pulse, from the end of shorted clipping line Z104, returns to the junction of the three delay lines with reversed phase, canceling the input. The electrical length of Z104 thus determines the width of the pulse. The pulse travels down Z103 to the sampling gate.

Delay lines Z101 to Z104 consist of the four sections of preformed, semirigid, 50-ohm coaxial cable mounted on the top board.

DG-2.3 DIGIT OSCILLATOR.

The Digit Oscillator assembly is mounted at the rear of the DI-3 module. The circuit contains one transistor, Q401, connected as a Colpitts oscillator with the base at rf ground.

Manual tuning is accomplished by switch selection of one of the 7 preset coils, L401 to L407. The appropriate coil is selected by S401, the only operating control on the module. The 2-section 7-position rotary switch and the 7 coils surrounding it are mounted on the aluminum plate at the rear of the module.

The oscillator is also voltage-tunable (at AT404) by means of a dc voltage applied to varactor diodes CR401 and CR402. These diodes are in parallel for dc, since their cathodes are tied directly together and both anodes are grounded, one directly, the other through the oscillator coil. For the rf signal, however, the diodes are in series, since the rf appears across the oscillator coil; the voltage-variable capacitance represented by the two varactors in series is also across the oscillator coil and thus across the oscillating circuit.

As the dc voltage from AT404 to ground changes, the oscillator frequency changes correspondingly due to the action of the varactors. Dc power (+18 volts) enters this assembly at AT401 and a through connection feeds this B+ to the remainder of the DI-3 circuits, via AT405.

The rf output from the Digit Oscillator is taken from T401 a 4:1 stepdown, wide-band, toroid transformer in the collector circuit of Q401. This voltage is brought out at the bottom of the oscillator-circuit assembly at AT403 and is fed to the bottom board, where it drives the two high-frequency rf amplifiers described in paragraph DC-2.4.

DG-2.4 AMPLIFIER CIRCUIT.

The two high-frequency rf amplifiers used in the DI-3 module are mounted on the bottom board and are driven in parallel by the Digit Oscillator, one providing the output signal at J202, and the other driving the sampler in the servo loop.

The amplifier designs are essentially identical and consist of two stages each of a transformer-coupled, common-base amplifier. In each amplifier the transistors are in series for dc power, cutting

down on power drain and simplifying by-pass problems. The transformers are 2:1 step-down types, giving a 4:1 impedance transformation. Gain per stage is approximately 6 dB. Each amplifier has a forward-to-reverse gain ratio of approximately 70 dB, which effectively prevents disturbances at their outputs from affecting the Digit Oscillator.

The amplifier in the servo-loop consists of Q201/T201, Q202/T202. R202, the adjustable element in the input attenuator of the amplifier, controls the loop gain of the DI-3 by adjustment of the rf drive to the sampler.

The output amplifier is comprised of Q203/T203, Q204/T204. R214 adjusts the drive to the first stage, setting the rf output level of the DI-3. The output is brought from AT206 and AT207 via a coaxial cable to J202, a subminiature coaxial connector that projects below the module, into the sandwich area. A short patch cord connects the output to the OMM-3 mixer module. A metal plate, under the connector, provides additional ground points for the module cover.

DG-2.5 SAMPLER AND DC AMPLIFIER SYSTEM.

DG-2.5.1 GENERAL.

The top board of the DI-3 contains the balance of the circuitry in the servo loop, including the pulse generator described in paragraph DG-2.2. The remainder of the circuits in the system include the sampler and dc control amplifier, described in the following paragraphs.

DG-2.5.2 SAMPLER.

The sampler is a normally closed gate circuit. This gate is "opened" on command from the 5-MHz repetition-rate pulse from the pulse generator described in paragraph DG-2.2. The gate remains open only for the duration of the pulse, 1 nanosecond. When the gate is open, the impedance between AT101 and the top of C105 is very low; otherwise it is very high.

The gating function is performed by the two high-speed sampling diodes, CR101 and CR102. The circuit is arranged so that the diodes are normally back biased by the voltage divider, R101, R102 and R103. A sampling pulse advancing down Z103 is converted by T103 to balanced drive for the sampler. The current in this pulse turns the diodes on through C101 and C102. The self-inductance of transformer T101 prevents it from short circuiting this very short-duration pulse. The digit-oscillator signal, however, fed in parallel to the windings of T101, appears directly on capacitors C101 and C102. Thus, when CR101 and CR102 conduct, the path through these diodes in parallel is the primary circuit between AT101 (the feedpoint for the rf) and C105, the sample-hold capacitor. C105 therefore charges very rapidly to the instantaneous rf level.

When the gate is closed, holding capacitor C105 is thus left with a charge proportional to the instantaneous level of the rf at AT101, at the time the last sample was taken. C105, when the gate is closed, is loaded only by a very high impedance determined by the Q101A bias current and the reverse leakage current through the diodes; it therefore discharges very slowly. The dc component of current in these two discharging loads is canceled by a current fed to this point of the circuit by R104, a 4.3-MΩ resistor. This current is determined by the setting of R105, which is adjusted so that the value of the sample charge in C105 (and the voltage across C105) is retained with minimum change, until replaced by the next sample, 200 ns later.

DG-2.5.3 DC AMPLIFIERS.

The dc amplifier in the servo loop consists of Q101, a differential-amplifier transistor pair in a single case, and Q102. The over-all voltage gain with feedback is about 6 and is designed for zero offset and minimum drift. This amplifier provides a low source impedance for the filters in the oscillator-control circuit, minimum loading on C105, and additional loop gain.

A 5 MHz notch filter (consisting of L104 and C107) is in series with the control line of the oscillator, so that any 5-MHz component appearing at the output of the dc amplifier does not appear at the digit-oscillator control input. Such a signal, if present, would create 5-MHz fm sidebands on the output of the DI-3.

DG-2.6 RECAPITULATION – OSCILLATOR CONTROL LOOP.

In the preceding paragraphs, the individual parts of the oscillator locking system have been described. These elements make up the oscillator locking scheme, to maintain the selected frequency outputs of the DI-3 at strict multiples of the incoming 5-MHz signal.

In review, the rf output of the digit-oscillator is sampled at a 5-MHz rate controlled by the 5-MHz input. If the frequency of the digit oscillator is exactly 30 times the input signal (5-MHz), exactly 30 cycles of the 150 MHz will occur between samples and the value of the sample will be exactly the same each time. Its value will depend on the phase and amplitude of the 150-MHz signal. Likewise, if the rf is exactly 120 MHz, 24 cycles will occur between samples and the value at the instant each sampling pulse occurs will again be the same as at the previous one. The output of the sampler, since the sample if "held" by C105, will therefore be dc, if the frequency is any exact multiple of the 5-MHz sampling rate. Thus, the sampling system can make no distinction as to which multiple is being observed, only that it is, in fact, a multiple of the sampling rate.

The output of the dc amplifier is connected to the digit-oscillator varactors, CR401 and CR402, (via AT108) and corrects the digit-oscillator frequency as required to establish the integral relationship of this frequency to 5 MHz, at a multiple as chosen by the position of switch S401.

Details of the frequency-correcting action of this servo loop are as follows. Unless the oscillator frequency is exactly correct, each sample will have a different voltage than the last, due to the phase drift of the input relative to the pulses. If the frequency is too low, each succeeding sample will have a higher voltage than the last (assuming the samples are being taken on the negative slope of the sinewave). This will place a higher voltage on the varactors, which lowers their capacitance and raises the frequency of the oscillator. In a like manner, if the frequency is too high, a lower voltage will appear at the output of the sampler from one sample to the next, which will reduce the varactor voltage and lower the oscillator frequency. Thus, in equilibrium, the voltage from the sampler is determined by the phase of the oscillator with respect to the sampling pulses, and adjusts itself continuously, as necessary, to maintain the oscillator frequency at an exact multiple of the sampling frequency.

DG-2.7 LAMP-CONTROL CIRCUIT.

This circuit is mounted on the front etched-circuit board of the DI-3 and functions to extinguish the pilot light in front of the DI-3, if the reference signal is present but the oscillator fails to lock. This function is accomplished by sensing for the presence of ac on the oscillator control line. If ac is present, this implies that either the oscillator is not locked or the phase-lock loop is self-oscillating, either condition being a malfunction. Ac amplifier Q301 will amplify any ac present on the oscillator control line. If any ac is present, it is detected by CR301 and CR302. This changes the bias on Q302, driving Q302 out of conduction. If this occurs, the voltage on the lamp-control pin drops to zero and the lamp-control transistor on the chassis lamp-panel assembly cuts off and extinguishes the lamp. (Refer to Section BC, on the chassis, for discussion of the operation of this circuit.)

SECTION DG-3

SERVICE AND MAINTENANCE

DG-3.1 INTRODUCTION.

If the system fault-localization procedure of Section 5 of the front portion of the manual indicates possible malfunction of the DI-3 unit, the most positive verification of this suspicion is the substitution of another DI-3 unit.

NOTE

Other DI units may not be subsituted for a DI-3.

If this step restores the instrument to normal operation, the defective DI-3 should, if possible, be returned to the General Radio Company for service and repair, especially if it is within the two-year warranty.

Since there is but one DI-3 unit per Type 1164 synthesizer, and since service spares may not be available, it will not always be possible to make the substitution as outlined above. Where this is not possible, selected tests and a few alignment steps may be made in the field. The synthesizer cannot operate without a properly functioning DI-3 module.

CAUTION

Most alignment procedures require the use of special test fixtures and cannot be accomplished in the field.

A thorough knowledge of the principles of operation, and all of the circuit arrangements by which the desired operation is achieved, is essential before DI-3 module service is attempted.

DG-3.2 TEST EQUIPMENT.

Recommended test equipment is listed and described in Table DG-1; equivalent equipment may be substituted.

TABLE DG-1

TEST EQUIPMENT

Function	*Type Recommended*	*Minimal Characteristics*
Electronic Voltmeter (VTVM)	GR 1806 with 1806-P1 probe	2% accuracy; ac and dc capabilities
Dual-Trace Oscilloscope	Tektronix 543 (with C/A plug-in and P6006 10x passive probe)	20 MHz, 0.5 V/cm with 8 pF (or less) probe capacitance
Alignment Tool	JFD No. 5284	Insulated soft-tip screwdriver
Sampling Oscilloscope	Tektronix 661 with 4S1 and 5T1A plug-in and P6032 CF probe	1000 MHz; high-impedance probe
Digital Counter	GR 1143	Up to 500 MHz with 7-place readout
Standard Sweep Frequency Generator	GR 1025	Calibration accuracy – 0.5%

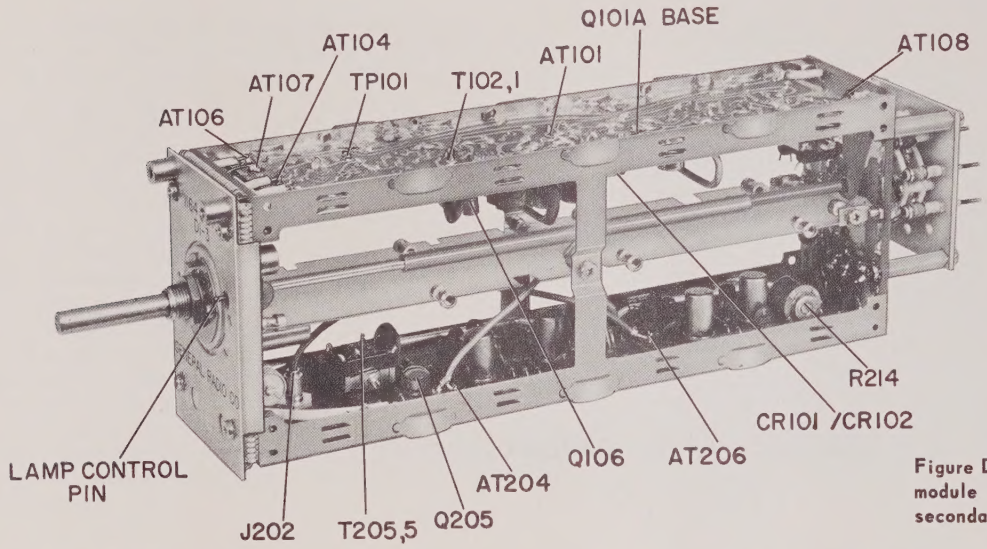


Figure DG-4. Interior of DI-3 module showing test points and secondary adjustment controls.

DG-3.3 TROUBLE ANALYSIS.

CAUTION

Turn power off during set-up changes to avoid accidental short circuits.

DG-3.3.1 GENERAL.

Remove the Type 1164 from its cabinet. Remove the DI-2 module from Station II, and remove the DI-3, after disconnecting the short coaxial cable at the bottom of the synthesizer. Disconnect the cable from J101 on the OMM-3 module (Figure DG-6), lift it out with the module. For other procedural details refer to paragraph 5.4.2 in the front portion of this manual.

Remove the 6 side screws and two bottom screws from the DI-3 module and slide the cover off. Reinstall the module (less cover) on the chassis. The DI-2 does not have to be reinstalled at this time.

Refer to Figures DG-4 and DG-5 for the locations of test points and secondary adjustments referred to in procedures that follow. See also Figure DG-14, the over-all schematic diagram.

The most common symptoms of failure within the DI-3 will be the generation of improper frequencies or the failure to give any output whatever. Procedures that

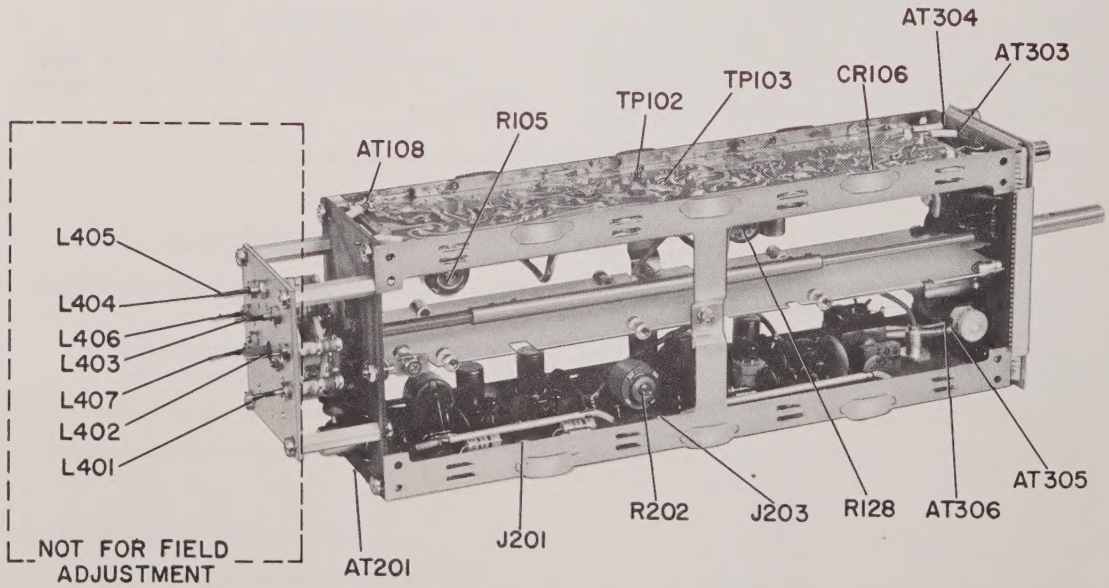


Figure DG-5. Interior of DI-3 module showing test points and secondary adjustment controls. DO NOT CHANGE SETTING OF L401-L407.

follow will give assurance that the difficulty is in the DI-3 module and not in some other unit and will facilitate fault isolation to the detail-part level.

DG-3.3.2 POWER INPUT.

With the VTVM, look for +18 ±0.2 Vdc at AT106 on the top circuit board. If the indication is abnormal, look at J201 the bottom circuit board of the DI-3. If the voltage is correct at J201, but is incorrect elsewhere, the malfunction is in the DI-3. If J201 indicates an incorrect voltage, check the power supply and chassis power distribution in the sandwich deck (refer to Sections GB and BC).

DG-3.3.3 5-MHz CIRCUITS.

With the oscilloscope, look for the 5-MHz input from the AFS module at J203. If the input signal is missing, distorted, or less than 0.25 V, rms, check the Main Frame (Section BC) and the AFS (Section CA). This test is independent of the setting of the synthesizer front-panel controls.

If the 5-MHz input is normal, observe the 5 MHz at pin 5 of T205. If no 5 MHz signal is present, the 5-MHz buffer stage, Q205, is inoperative. Next, observe the waveform at TP101 (top board, foil side). It should appear as in Figure DG-7 (A). T205 can be adjusted to maximize this signal.

If no signal is present, check the pulse-clipper stages, Q103 and Q104, the drive signal to Q103 (at AT104), and the crystal filter. Inputs to the crystal filter can be observed at AT305 and AT306 and output at AT303 and AT304 (front board).

A sweeping frequency source of narrow range, such as a Type 1163-A7C synthesizer equipped with Type 1160-P2 Sweeper accessory, is required to check the characteristic of the crystal filter, along with a means of connecting it into the instrument. This is not normally a field adjustment.

DG-3.3.4 PULSE CIRCUITS.

The simplest approach to isolate trouble in Q103-Q106 is to signal-trace the various waveforms until a defective circuit is located. Figure DG-7 (B) shows the waveform at the collector of Q104, the input to the pulse clipper; the output at the emitter of Q105 is shown at Figure DG-7 (C).

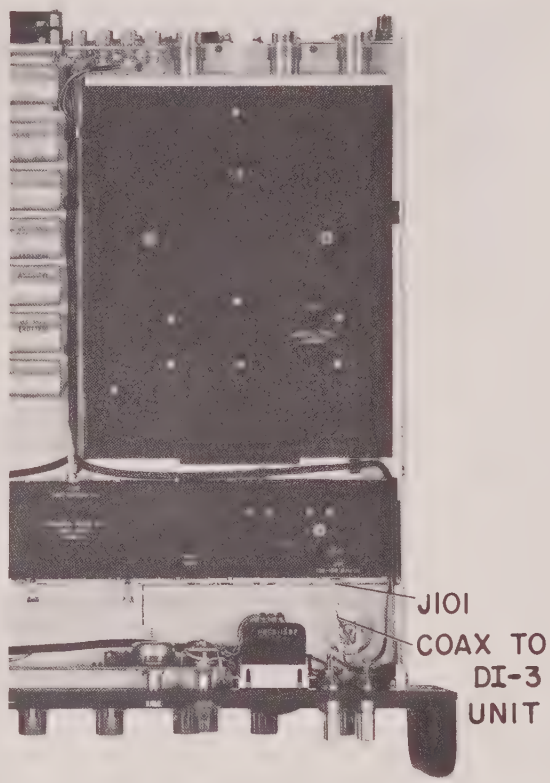


Figure DG-6. Rf output connector on DI-3 module, shown looking from underside of the synthesizer.

R128 controls the amplitude of the blocking-oscillator pulse, the waveform of which can be observed at the collector of Q106 (case).

CAUTION

Do not change the setting of R128 unless there is a strong reason to do so, since a change in pulse amplitude can upset the sampler balance.

The sampling oscilloscope is needed for the remainder of the pulse circuits. Figure DG-8 (A) shows the output of the blocking oscillator at pin 1, T102, (use Figure DG-10 to find the test point). Figure DG-8 (B) shows the waveform at the anode of CR106. CR106, a plug-in unit, is selected to give the stored-charge, snap-off characteristics necessary to speed up the blocking-oscillator pulse.

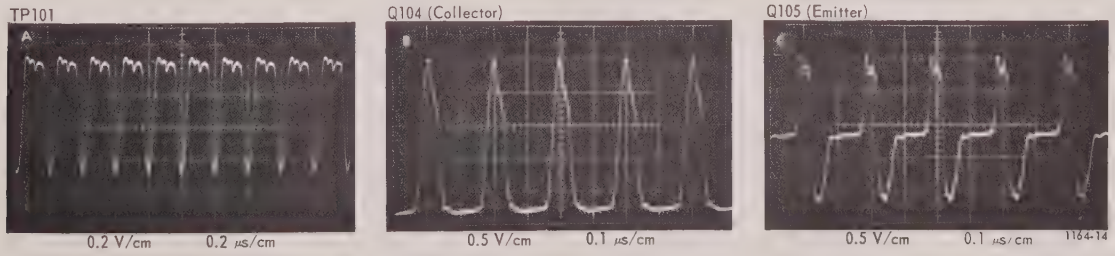


Figure DG-7. Typical waveforms for the servo-circuit (see Figure DG-10).

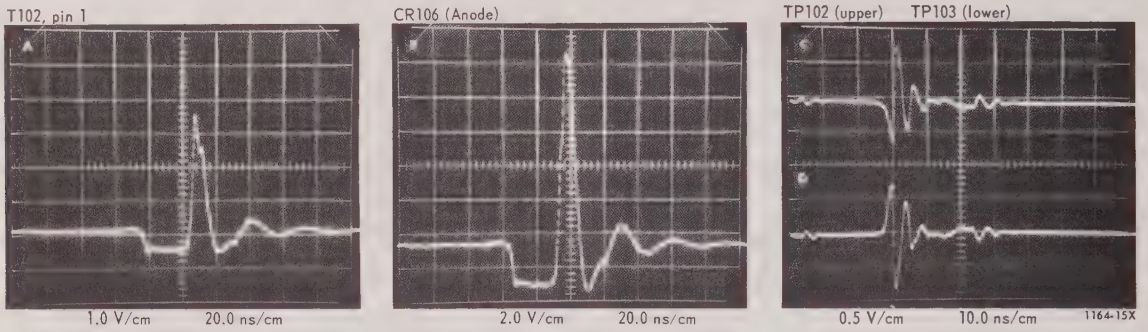


Figure DG-8. Sampling oscilloscope waveforms typical of servo-circuit blocking-oscillator performance.

The waveforms of the remainder of the pulse circuits are checked best when the Digit Oscillator is not running. To stop the oscillator, set the digit dial between steps. Observe the waveforms at TP102 and TP103; see Figure DG-8 (C and D). Diodes CR101 and CR102 must be removed for this test. They are plug-in units in the top circuit board (Figure DG-4). Note carefully the relative positions and polarizations of the diodes on the board prior to removal, so that they can be reinstalled exactly as they were originally. Turn off power prior to removal, or reinstallation.

Switch the digit selector back to one of the dial positions to restore operation of the Digit Oscillator. Reinstall the diodes.

CAUTION

Error in reinstallation of these diodes can adversely affect calibration of the phase-lock loop.

DG-3.3.5 RF CIRCUITS.

A rough estimate of the performance of the 120 to 150-MHz sections of the DI-3 module can be made by signal tracing with the oscilloscope and VTVM (see Figure DG-5).

A frequency equal to the digit-output frequency should be found progressively at the following points: AT201 at approximately 0.95 V, rms; AT206 (rf output) 0.3 V, rms (adjustable by R214); and AT204 and AT101 at about 50 - 100 mV, rms, depending on the factory setting of servo control loop-gain, (see Figure DG-5 for test points).

If gain control R202 or other elements in the servo loop become faulty or misadjusted, the servo-control circuit may oscillate and inhibit normal phase-lock operation. Figure DG-9 is indicative of this symptom, as seen at AT107. This condition cannot be adjusted in the field.

CAUTION

Do not change the setting of R202.

DG-3.3.6 DC AMPLIFIER.

Table DG-2 includes the voltages that should be obtained in the dc amplifier circuits.

DG-3.3.7 NOTCH FILTER.

Remove Q106 to stop the pulse generator. Connect the VTVM (dc mode) to AT108 and adjust R105 to a 6.0 Vdc indication; a right-angle screwdriver can be used for this adjustment.

Connect two 33 kilohm resistors to the base of Q101A, one going to TP102 and the other to TP103, (across the diodes), to maintain the bias on Q101A. Connect the signal generator, to the base of Q101A, through a 0.01-μF coupling capacitor. Sweep through 5 MHz at 0.1 V, rms, and with the VTVM (ac mode), observe the voltage at AT108. The ac voltage output of the amplifier should go through a minimum at 5 MHz. If the notch can't be found, the unit must be returned to General Radio for realignment.

DG-3.4 DC VOLTAGE CHECKS.

The procedures in paragraph DG-3.3 should narrow the search for circuit defects to a circuit function consisting of one, or at the most, a few stages. As a further aid to pinpointing the defective part, the information on dc voltage readings is presented in Table DG-2.

TABLE DG-2
DC VOLTAGE INDICATIONS

Transistor	*Emitter*	*Base*	*Collector*
Q101A	5.5	6.0	14.5
Q101B	5.5	6.0	18.0
Q102	15.0	14.5	6.0
Q103	9.4	9.0	0
Q104	9.4	9.0	0
Q105	0	0	15.0
Q106	0	-0.5	2.3
Q201	3.0	3.7	8.6
Q202	11.5	12.0	17.5
Q203	2.8	3.6	8.6
Q204	11.0	12.0	17.5
Q205	9.6	9.0	0
Q301	5.4	6.0	11.0
Q302	0.64	0.44	0.60
Q401	7.0	7.6	17.0

DG-3.5 REPAIRS AND REPLACEMENT.

Replace defective detail parts (with frequency-insensitive functions) to correct deficiencies indicated by the trouble-analysis procedures.

CAUTION

Replacement of frequency-determining parts will require realignment which cannot be accomplished without special test fixtures.

Figures DG-10 through DG-13 show the physical layout of the parts on the various etched-circuit boards, to speed positive identification. The reference designators for the parts shown on the boards are the same as those used in the over-all schematic diagram, Figure DG-14, and in the parts list at the end of this section.

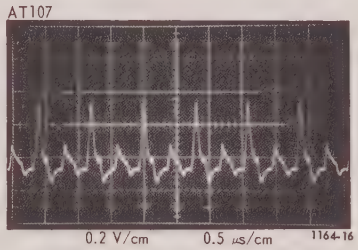


Figure DG-9. Typical waveform at AT107 indicating self-oscillation resulting from an incorrect setting of R202, the Digit Oscillator control-loop gain control.

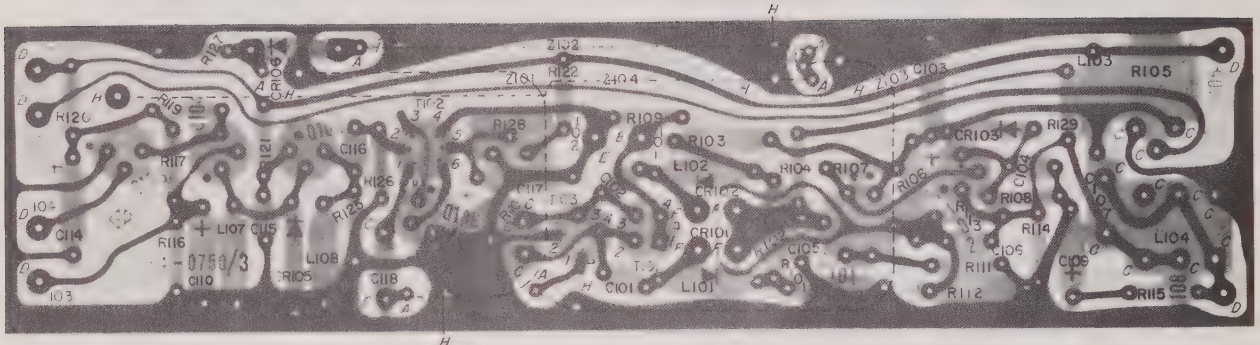


Figure DG-10. Etched-circuit board assembly (top) for DI-3 (P/N 1164-2756).

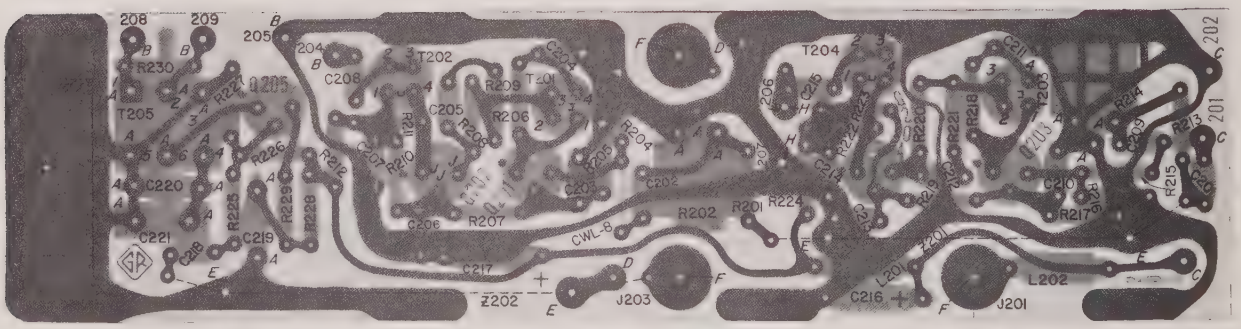


Figure DG-11. Etched-circuit board assembly (bottom) for DI-3 (P/N 1164-2776).

NOTE: The number appearing on the foil side is not the part number. The dot on the foil at the transistor socket indicates the collector lead.

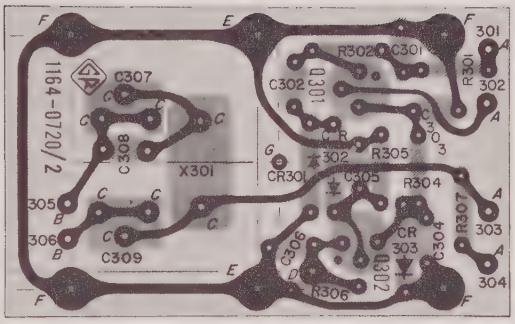


Figure DG-12. Etched-circuit board assembly (front) for DI-3 (P/N 1164-2720).

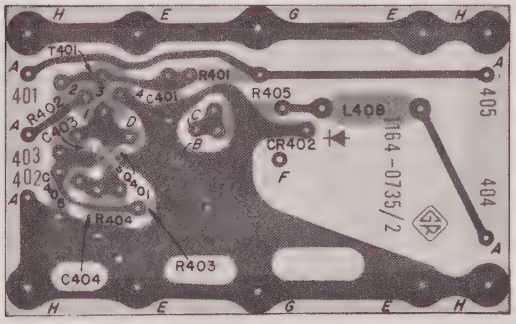


Figure DG-13. Etched-circuit board assembly (rear) for DI-3 (P/N 1164-2736).

NOTE: The number appearing on the foil side is not the part number. The dot on the foil at the transistor socket indicates the collector lead.

PARTS LIST

REF NO	DESCRIPTION	PART NO
	CAPACITORS	
C101	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C102	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C103	Electrolytic, 2.2 μF ±20% 20 V	4450-4500
C104	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C105	Ceramic, 6.2 pF (N30) ±5% 500 V	4411-9625
C106	Ceramic, 7.5 pF (N30) ±5% 500 V	4411-9755
C107	Mica, 62 pF ±1% 500 V	4710-0004
C108	Ceramic, 15 pF (N750) ±5% 500 V	4417-0155
C109	Electrolytic, 2.2 μF ±20% 20 V	4450-4500
C110	Electrolytic, 1.0 μF ±20% 35 V	4450-4300
C114	Electrolytic, 1.0 μF ±20% 35 V	4450-4300
C115	Ceramic, 0.0047 μF +80-20% 500 V	4405-2479
C116	Ceramic, 470 pF ±10% 500 V	4405-1478
C117	Electrolytic, 1.0 μF ±20% 35 V	4450-4300
C118	Ceramic, 0.02 μF +80-20% 50 V	4402-3200
C201	Ceramic, 0.001 μF ±10% 500 V	4405-2108
C202 thru C215	0.001 μF ±10% 500 V	4405-2108
C216	Electrolytic, 1.0 μF ±20% 35 V	4450-4300
C217	Electrolytic, 1.0 μF ±20% 35 V	4450-4300
C218	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C219	Ceramic, 0.02 μF +80-20% 50 V	4402-3200
C220	Ceramic, 20 pF (N750) ±5% 500 V	4417-0205
C221	Mica, 100 pF ±1% 500 V	4710-0010
C301	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C302 thru C306	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C307	Trimmer, 7-5 pF (N300) 350 V	4910-2032
C308	Ceramic, 22 pF (NPO) ±5% 500 V	4410-0225
C309	Ceramic, 2-8 pF (NPO) 350 V	4910-2033
C401	Ceramic, 0.001 μF ±10% 500 V	4405-2108
C402	Ceramic, 5.1 pF (N30) ±5% 500 V	4411-9515
C403	Ceramic, 5.1 pF (N30) ±5% 500 V	4411-9515
C404	Ceramic, 51 pF ±5% 500 V	4404-0515
C405	Ceramic, 0.001 μF ±10% 500 V	4405-2108
	DIODES	
CR101	Semiconductor, assembly	1164-2010
CR102	Semiconductor, assembly	1164-2010
CR103	Semiconductor, type 1N746	6083-1005
CR105	Semiconductor, type 1N3604	6082-1001
CR106	Semiconductor, type 1N3604	6082-1001
CR301	Semiconductor, type 1N191	6082-1008
CR302	Semiconductor, type 1N191	6082-1008
CR303	Semiconductor, type 1N645	6082-1016
CR401	Semiconductor, type VA-135	6084-1011
CR402	Semiconductor, type VA-135	6084-1011
	INDUCTORS	
L101	Choke, iron core 1.5 μH ±10%	4300-1000
L102	Choke, iron core 1.5 μH ±10%	4300-1000
L103	Choke, iron core 22 μH ±10%	4300-2600
L104	Ferrite cup, adjustable	5000-2838
L107	Choke, iron core 22 μH ±10%	4300-2600
L108	Choke, iron core 1.5 μH ±10%	4300-1000
L201	Choke, iron core 22 μH ±10%	4300-2600
L202	Choke, iron core 22 μH ±10%	4300-2600
L401	Ferrite cup, adjustable	1164-2300
L402	Ferrite cup, adjustable	1164-2300
L403	Ferrite cup, adjustable	1164-2310
L404	Ferrite cup, adjustable	1164-2310
L405	Ferrite cup, adjustable	1164-2320
L406	Ferrite cup, adjustable	1164-2320
L407	Ferrite cup, adjustable	1164-2330
L408	Choke, iron core 4.7 μH ±10%	4300-1600

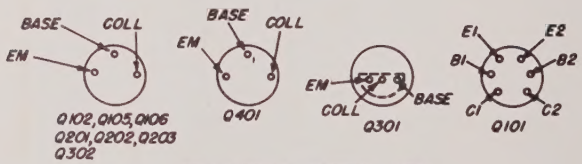
REF NO	DESCRIPTION	PART NO
	RESISTORS	
R101	Film, 5.76 kΩ ±1% 1/8 W	6250-1576
R102	Film, 402 Ω ±1% 1/8 W	6250-0402
R103	Film, 11.8 kΩ ±1% 1/8 W	6250-2118
R104	Composition, 4.3 MΩ ±5% 1/4 W	6099-5435
R105	Potentiometer, composition 100 kΩ ±20%	6040-1000
R106	Film, 2 kΩ ±1% 1/8 W	6250-1200
R107	Composition, 10 kΩ ±5% 1/4 W	6099-3105
R108	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475
R109	Composition, 47 Ω ±5% 1/4 W	6099-0475
R110	Potentiometer, composition 100 kΩ ±20%	6040-0100
R111	Composition, 5.6 kΩ ±5% 1/4 W	6099-2565
R112	Film, 1 kΩ ±1% 1/8 W	6250-1100
R113	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335
R114	Composition, 1.2 kΩ ±5% 1/4 W	6099-2125
R115	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475
R116	Composition, 10 kΩ ±5% 1/4 W	6099-3105
R117	Composition, 10 kΩ ±5% 1/4 W	6099-3105
R119	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335
R120	Composition, 100 Ω ±5% 1/4 W	6099-1105
R121	Composition, 330 Ω ±5% 1/4 W	6099-1335
R122	Composition, 680 Ω ±5% 1/4 W	6099-1685
R125	Composition, 150 Ω ±5% 1/4 W	6099-1155
R126	Composition, 390 Ω ±5% 1/4 W	6099-1395
R127	Composition, 220 Ω ±5% 1/4 W	6099-1225
R128	Potentiometer, wire-wound 2 kΩ ±5%	6053-1105
R129	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335
R201	Composition, 330 Ω ±5% 1/4 W	6099-1335
R202	Potentiometer, composition 100 Ω ±20%	6040-0100
R204	Composition, 390 Ω ±5% 1/4 W	6099-1395
R205	Composition, 1.8 kΩ ±5% 1/4 W	6099-2185
R206	Composition, 470 Ω ±5% 1/4 W	6099-1475
R207	Composition, 3.9 kΩ ±5% 1/4 W	6099-2395
R208	Composition, 390 Ω ±5% 1/4 W	6099-1395
R209	Composition, 33 Ω ±5% 1/4 W	6099-0335
R210	Composition, 2.2 kΩ ±5% 1/4 W	6099-2225
R211	Composition, 680 Ω ±5% 1/4 W	6099-1685
R212	Composition, 47 Ω ±5% 1/4 W	6099-0475
R213	Composition, 150 Ω ±5% 1/4 W	6099-1155
R214	Potentiometer, composition 100 Ω ±20%	6040-0100
R215	Composition, 15 Ω ±5% 1/4 W	6099-0155
R216	Composition, 220 Ω ±5% 1/4 W	6099-1225
R217	Composition, 1.8 kΩ ±5% 1/4 W	6099-2185
R218	Composition, 3.9 kΩ ±5% 1/4 W	6099-2395
R219	Composition, 3.9 kΩ ±5% 1/4 W	6099-2395
R220	Composition, 220 Ω ±5% 1/4 W	6099-1225
R221	Composition, 33 Ω ±5% 1/4 W	6099-0335
R222	Composition, 680 Ω ±5% 1/4 W	6099-1685
R223	Composition, 2.2 kΩ ±5% 1/4 W	6099-2225
R224	Composition, 47 Ω ±5% 1/4 W	6099-0475
R225	Composition, 470 Ω ±5% 1/4 W	6099-1475
R226	Composition, 15 kΩ ±5% 1/4 W	6099-3155
R227	Composition, 15 kΩ ±5% 1/4 W	6099-3155
R228	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335
R229	Composition, 22 Ω ±5% 1/4 W	6099-0225
R230	Composition, 120 Ω ±5% 1/4 W	6099-1125
R301	Composition, 220 Ω ±5% 1/4 W	6099-1225
R302	Composition, 820 Ω ±5% 1/4 W	6099-1825
R304	Composition, 680 Ω ±5% 1/4 W	6099-1685
R305	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475
R306	Composition, 330 Ω ±5% 1/4 W	6099-1335
R307	Composition, 680 Ω ±5% 1/4 W	6099-1685
R401	Composition, 150 Ω ±5% 1/4 W	6099-1155
R402	Composition, 10 kΩ ±5% 1/4 W	6099-3105
R403	Composition, 10 kΩ ±5% 1/4 W	6099-3105
R404	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R405	Composition, 220 Ω ±5% 1/4 W	6099-1225

REF NO	DESCRIPTION	PART NO
	TRANSISTORS	
Q101	Type 2N2453	8210-1046
Q102	Type 2N3250	8210-1089
Q103	Type 2N3638	8210-1096
Q104	Type 2N3638	8210-1096
Q105	Type 2N708	8210-3089
Q106	Type 2N2369	8210-1052
Q201	Type 2N918	8210-1066
Q202	Type 2N918	8210-1066
Q203	Type 2N918	8210-1066
Q204	Type 2N918	8210-1066
Q205	Type 2N3638	8210-1096
Q301	Type 2N3390	8210-1077
Q302	Type 2N1305	8210-1305
Q401	Type 2N3478	8210-1111
	MISCELLANEOUS	
Z101	CABLE, Delay line, rigid-wall coaxial, miniature	1163-0201
Z102	CABLE, Delay line, rigid-wall coaxial, miniature	1163-0202
Z103	CABLE, Delay line, rigid-wall coaxial, miniature	1163-0203
Z104	CABLE, Delay line, rigid-wall coaxial, miniature	1163-0204
Z201	CABLE, Delay line, rigid-wall coaxial, miniature	1164-0200
Z202	CABLE, Delay line, rigid-wall coaxial, miniature	1164-0205
Z203	CABLE, Delay line, rigid-wall coaxial, miniature	1164-2410
X301	CRYSTAL, 5 Mc	1213-0440
J201	JACK, etched-circuit eyelet-type	1160-6110
J202	JACK, etched-circuit eyelet-type	
	Part of Z203	4260-1310
J203	JACK, etched-circuit eyelet-type	1160-6110
S401	SWITCH, rotary wafer	7890-4480
T101	TRANSFORMER, video, interstage	5000-2403
T102	TRANSFORMER, video, interstage	5000-2601
T103	TRANSFORMER, video, interstage	5000-2403
T201 thru T204	TRANSFORMER, video, interstage	5000-2403
T205	TRANSFORMER, video, interstage	5000-2837
——	Knob, dial assembly	1164-1030
——	Lamp assembly	1160-2800
	CIRCUIT BOARD – ASSEMBLIES	
	Top circuit board	1164-2756
	Bottom circuit board	1164-2776
	Front circuit board	1164-2720
	Rear circuit board	1164-2736

Rotary switch sections are shown as viewed from the panel end of the shaft. The first digit of the contact number refers to the section. The section nearest the panel is 1, the next section back is 2, etc. The next two digits refer to the contact. Contact 01 is the first position clockwise from a strut screw (usually the screw above the locating key), and the other contacts are numbered sequentially (02, 03, 04, etc), proceeding clockwise around the section. A suffix F or R indicates that the contact is on the front or rear of the section, respectively.

NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 1/4 WATT.
5. RESISTANCE IN OHMS K 1000 OHMS M 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS. LESS THAN ONE IN MICROFARADS.
7. ◯ KNOB CONTROL
8. ⊘ SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT



TRANSISTORS BOTTOM VIEW

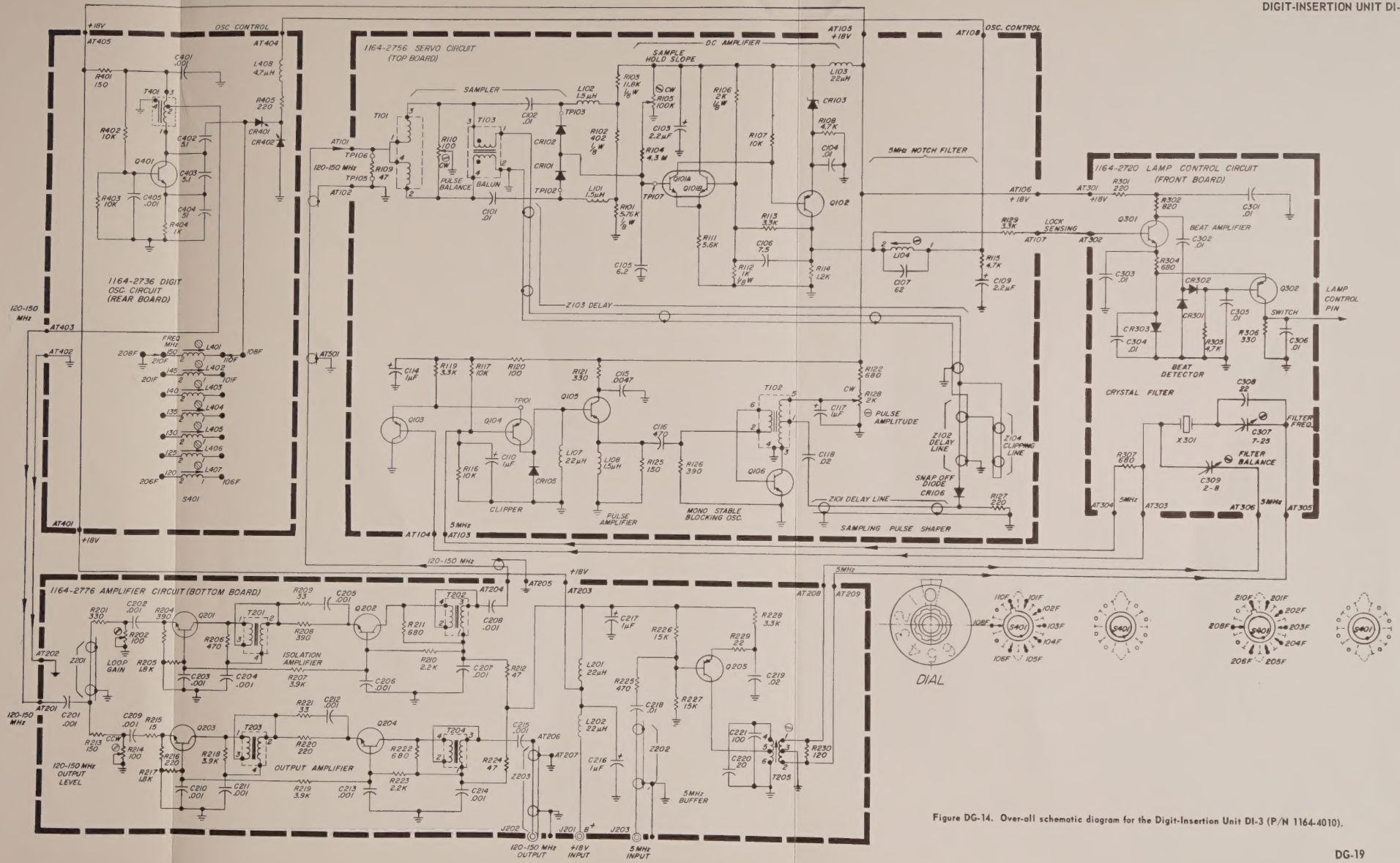


Figure DG-14. Over-all schematic diagram for the Digit-Insertion Unit DI-3 (P/N 1164-4010).